

CHAPTER 3

BASELINE ASSESSMENT OF DoD M&S

A. INTRODUCTION

1. Before 1990, DoD M&S was fragmented and uncoordinated across key communities (e.g. , between DoD Components and across functional communities) . In recognition of these deficiencies, Congress directed the Department of Defense to "... establish an Office of the Secretary of Defense (OSD) level joint program office for simulation to coordinate simulation policy, to establish interoperability standards and protocols, to promote simulation within the military departments, and to establish guidelines and objectives for coordination [sic] of simulation, war-gaming, and training. " (Senate Authorization Committee Report, reference (b)). Consistent with this direction, the DMSO was created, and shortly afterwards key DoD Components designated organizations and/or points of contact to facilitate coordination of M&S activities within and across their communities. As a consequence, there is better sharing of information, capabilities, and resources within and among key DoD M&S communities. However, most users still lack the M&S services they desire. Many potential M&S applications (e.g., Command and Control Warfare (C2W), logistics, OOTW, space systems, manufacturing and C4I) have not been addressed adequately, and major technical challenges loom ahead.

2. These institutional changes facilitated significant advances in M&S in four areas: architectures, standards, and protocols; representation of the environment, systems, and human behavior; fielding of M&S and associated infrastructure; and outreach activities. Nonetheless, major shortfalls that warrant concerted actions by the Department of Defense persist in each of these areas. This is to be expected in so ambitious an effort as is required to realize the DoD vision for M&S.

B. ARCHITECTURES, STANDARDS, AND PROTOCOLS

1. Two recent Defense Science Board (DSB) Task Forces (Reports on Advanced Distributed Simulation and Readiness, references (c) and (d)) have recommended that architectural⁴ efforts to combine live⁵, virtual⁶, and constructive simulation be broadened. In addition, recent special studies have noted the need for architectural activities to promote the interoperability and reuse of models and simulations to support other functional areas such as acquisition (Report on M&S, reference (e)) . Interoperability and

⁴ See definition 4.

⁵ See definition 35.

⁶ See definition 58.

⁷ See definition 12.

reuse are limited because the Department of Defense lacks a common technical framework for simulation architecture. There is now a consensus that DoD must establish such a framework to facilitate the interoperability of all types of models and simulations among themselves and with C4I Systems, as well as to facilitate the reuse of M&S components.

2. Recent efforts have built upon the foundation established by the Advanced Research Projects Agency (ARPA) in the Simulation Network (SIMNET) program to develop Distributed Interactive Simulation (DIS) standards and protocols (e.g., Institute of Electrical and Electronic Engineers (IEEE) Standard 1278) . The DIS protocols and standards establish a common data exchange environment, also known as a common messaging environment, using Protocol Data Units, that supports the interoperability of heterogeneous, geographically-distributed, live, virtual and constructive simulations . A strength of the DIS standards development process is its open forum, with broad participation of representatives from government, industry, and academia. The potential exists for DIS to satisfy a broader set of needs than it does today. There is a need to significantly expand DIS and evolve its architecture to support a broader range of capabilities (e.g. , to reflect dynamic changes in the environment, support simulations with different time management methods, represent command and control more realistically, and to reduce its computational and communication bandwidth demands (e.g., by switching from its heavy reliance on broadcast) . With the anticipated correction of these problems, DI-S is expected to serve a central role in the evolution of DoD M&S capabilities.

3. In the area of constructive war games, a 1988 DSB Task Force on Computer Applications to Training and Wargaming (Report on Computer Applications to Training and Wargaming, reference (f)) observed that most constructive simulations used by the Services for training were not interoperable and recommended that steps be taken to redress this shortfall. In partial response, ARPA developed the Aggregate Level Simulation Protocol (ALSP) to interconnect theater-level constructive simulations (Aggregate Level Simulation Protocol, reference (g)) . The resulting confederation of Service simulations (e.g., Corps Battle Simulation; Air Warfare Simulation; Research, Evaluation, and System Analysis) has been assembled and used with success in supporting a wide spectrum of joint and combined training exercises (e.g., ATLANTIC RESOLVE, UNIFIED ENDEAVOR, ULCHI FOCUS LENS). ALSP confederations will remain a cornerstone of joint force-level training until the Joint Simulation System reaches Initial Operating Capability. Because the ALSP confederation simulations were originally developed in isolation, they have only limited interoperability, take a long time to set up, and require many people to operate.

4. Recent applications of M&S to train Joint and Service staffs have highlighted the need to interface simulations with C⁴I systems. The current generation of simulations is designed with

unique computer workstations as the primary means for the user to interface with the simulation. This presents an unrealistic training environment to the warfighter and requires specially trained personnel to operate the workstations and to interact with the training audience. Interfacing simulations with real-world systems is necessary to enhance training capabilities and facilitate the use of M&S to support real-time operational decision-making.

5. Security is a significant concern in DoD M&S. The conduct of distributed simulations of real-world operations has heightened community awareness of multi-level security (MLS) needs. Progress has been made in the development of encryption and/or decryption devices for the transfer of classified data among distributed sites. However, current security capabilities drive the M&S community to the conduct of system-high exercisers. The throughput limits of current encryption devices limit the scale of simulation exercises, and current efforts to address the needs of MLS and multiple communities (e.g., U.S. ONLY, U.S./North Atlantic Treaty Organization, U.S./Republic of Korea) are inadequate. In addition to technical problems, there are also several security policy issues (e.g., disparate security classifications of training simulations among the Services, use of cryptographic equipment by allies) that must be addressed.

6. Data standards, data quality, and data security requirements are an essential part of the M&S technical framework. The DMSO has been designated the Functional Data Administrator (FDAd) for the M&S community. The M&S FDAd has submitted the first Data Administration Strategic Plan (DASP) (reference (h)). Under MSWG sponsorship, a Data and Repositories Technology Working Group (DRTWG) consisting of more than one hundred representatives, has developed a well-defined set of needs and plans for the M&S community. A standard set of data administration policy⁸ and procedures needs to be developed for the M&S community to address such subjects as complex data⁹ (e.g. probability hit/kill, images, road networks); the verification, validation, and certification (W&C) of data; authoritative data sources; and data security.

C. REPRESENTATIONS OF THE ENVIRONMENT, SYSTEMS, AND HUMAN BEHAVIOR

The representations of the environment, systems, and human behavior, along with the processes by which these representations interact, are, at present, shared inadequately across the DoD M&S community.

⁸ System-high exercises require that the entire exercise be declassified at the highest level of classified information that is used in the exercise.

⁹ See definition 10

1. Representation of the Environment. Impressive representations of the terrain have been achieved, but these databases are largely non-reusable by different simulations and take too much time, money and people to produce. A recent DSB Task Force (Report on Advanced Distributed Simulation, reference (c)) recommended that "DoD must continue research and development (R&D) and maturing activities for reusable terrain and environmental databases. " In addition, several operational users have called for the development of the capability to generate environmental representations rapidly, to satisfy operational planning and mission rehearsal requirements. The DMA has implemented a Digital Production System that has begun the process of automating the production of mapping, charting, and geodesy databases. Further progress in the representation of the environment across the Department of Defense is impeded by the lack of:

- a. A clear articulation of M&S community requirements for environmental data;
- b. A coherent management structure; and,
- c. An assured, stable, quality development process on which program managers can depend.

These shortfalls have been highlighted by a recent DSB Task Force (reference (d)), which identified them as major impediments to "achieving desired levels of readiness.

2. Representation of Systems. The M&S community is exploring the development of authoritative models for representing military and non-military systems and units as a means of enhancing interoperability and reuse. As examples, the Army is developing a functional description of the battle space to assist in the development of object representations; the Air Force has developed an object-oriented environment; efforts are underway to develop a joint warfare simulation object library; and Defense Intelligence Production Centers are developing common approaches for representing threat forces and systems. However, at present, there are no broadly accepted community standards for representing military systems and organizations in M&S. Consequently, representations of the same system in different models are frequently incompatible. Shared community standards are required for the promises implicit in object oriented models to be realized. Once these standards have been developed and implemented, the level of effort associated with the generation of these products is still projected to be quite high. In several cases (e.g. representation of C⁴I systems and electronic warfare environments) , additional research and development will be required to understand how they can be modeled authoritatively. Consequently, a substantial long-term investment will be needed to achieve a fully populated set of system representations.

3. Representation of Human Behavior. The fully and semi-automated authoritative representations of friendly or threat forces (Report on Advanced Distributed Simulation, reference (c)) and other groups of humans under the stresses of conflict (Final Report of the Acquisition Task Force on M&S, reference (e)) are widely recognized as exceedingly challenging tasks. To respond to these challenges, the Department of Defense has undertaken two key R&D initiatives. The U.S. Army's Modular Semi-Automated Forces (ModSAF) program is attempting to provide a baseline, standardized, modular software structure in which model components have well-defined and documented interfaces. This structure is being implemented so that model behavior can be reconfigured in run-time. The program is also seeking to develop more sophisticated, generalized representations of behaviors, missions, and behavior control mechanisms. In its Command Forces program, ARPA is also developing technology to represent command and control in entity-based-simulations. However, there have been few efforts, to date, to represent tactical behavior authoritatively in operational programs. The Army's Close Combat Tactical Trainer program is a notable exception, in which the program manager began with user requirements, identified and collected the relevant behavior from subject matter experts, and developed authoritative representations of tactical behavior. In general, however, the representation of humans in models and simulations is extremely limited, particularly in the representation of opposing forces and their doctrine and tactics. In view of the limited theoretical underpinnings in this area, this issue will require extensive research before human behavior can be modeled authoritatively.

D. FIELDING OF M&S AND ASSOCIATED INFRASTRUCTURE. To realize fully the benefits of widespread usage of models and simulations, attention must be paid to the fielding of M&S systems, verification¹⁰, validation¹¹, and accreditation¹² (VV&A), M&S data VV&C, resource repositories, communications, and exercise management.

1. Fielding of Systems. In the past, the fielding of M&S systems has been designed to meet only the needs of the developing Component. To achieve the DoD M&S vision, Components developing M&S capabilities must design the systems to:

- a. Be interoperable and reusable;
- b. Support the operational needs of both active and reserve components;
- c. Support the needs of the Commanders in Chief;
- d. Address the full range of Defense missions; and

¹⁰ See definition 56.

¹¹ See definition 55.

¹² See definition 1.

e. Field M&S systems in adequate numbers to meet DoD-wide end-user needs. DoD operational requirements must be identified and an adequate plan must be developed to meet expected needs.

2. VV&A/VV&C. DoD Directive 5000.59 (reference (a)) directs each of the DoD Components to develop an approach to W&A that is appropriate to the models and simulations within its purview. "Consistent with this direction, some DoD Components have defined approaches to W&A (e.g. , Department of the Army Pamphlet 5-11, reference (i)) . Emphasis on M&S credibility has stimulated V&V activities to begin much earlier in model development and to become part of the M&S life cycle. Likewise, more discipline is being introduced into documentation of V&V activities that support accreditation. However, it is widely acknowledged that there are several issues that must be resolved before W&A can be regarded as a well-defined, routine process. First, the procedures for verification and validation (V&V) of new models, or of models used for new mission areas, need to be refined. Particular attention must be given to the issue of the relative costs and benefits associated with increasing levels of V&V (i.e., how much V&V is enough?) . Second, efforts are needed to develop tools to support W&A and to provide training in their use. Efforts are also required to build automated W&A tools to assist exercise and/or application designers as they are uniquely configuring their distributed simulations. Finally, procedures for accreditation need to be matured. In view of the criticality of the W&A process, these activities warrant high priority community action. Data VV&C as part of the M&S W&A process is essential to ensure credibility of M&S results.

3. Resource Repositories. Today, the Department of Defense does not have a robust, integrated system for sharing and maintaining models, simulations, data, metadata, algorithms, and tools . The M&S community has a requirement for a networked, distributed MSRR system to address its needs in this area. The DISA is developing a DoD Repository System (DDRS), of which an MSRR would be a sub-set. In coordination with DISA efforts, the DRTWG is developing a plan to identify requirements, design, and prototype an MSRR consistent with DISA's next generation DDRS. The objective of the DRTWG'S efforts is to develop unclassified and classified (secret system high) distributed systems to serve M&S clients in developing and using M&S and accessing and retrieving data. .

4. Communications. A reliable communications infrastructure with capacity adequate to support M&S does not yet exist. However, promising efforts to provide the special M&S communications needs are under way. The Defense Simulation Internet (DSI) has been implemented to support the needs of geographically distributed users. An ARPA/DISA Joint Program Office manages the DSI, and plans have been made to merge DSI with the Defense Research and Engineering Network (DREN) and to enhance the capacity and reli-

ability. The long-term objective is to use commercial services and operational communications capabilities to meet M&S needs. Additional challenges include the need for additional features (e.g., dynamic multicasting), latency reduction, bandwidth reduction, improvements in security, and expanded use of commercial communications.

5. Exercise Management. Recent experience in conducting large distributed M&S exercises (e.g., ATLANTIC RESOLVE, UNIFIED ENDEAVOR, ULCI FOCUS LENS 94, Synthetic Theater of War-Europe (STOW-E)) has highlighted the challenge of M&S management. In the future, the use of M&S capabilities by all Components will produce competition for resources and must meet the needs of the entire DoD M&S community. To facilitate the increased use of distributed M&S capabilities the Department of Defense must provide improved management of M&S assets and access to expertise in the planning and conduct of distributed M&S exercises.

E. OUTREACH ACTIVITIES

1. There has been a dramatic increase in the level of outreach activities that have been undertaken to enhance cross-community coordination, technology transfer, and exchange of information. These include increased participation at key conferences (e.g., demonstration of the ability to link heterogeneous virtual simulations at the Interservice and/or Industry Training Systems and Education Conference), increased interface efforts through professional societies (e.g., mini-symposia on W&A and simulation data sponsored by the Military Operations Research Society; workshops on C⁴I and M&S sponsored by the American Institute of Aeronautics and Astronautics; and the Intelligence Community M&S Coordinating Group's annual symposium), extended international involvement (e.g., increased efforts to address the development and application of international M&S standards among allies), creation of the Industry Steering Group on M&S, and active promotion of dual-use of DoD M&S technologies (e.g., participation on inter-agency task forces to expand the use of M&S technology in civilian education and training).

2. A number of task forces have called for an extended outreach program. Several of these task forces have recommended initiatives to educate and train key communities on the capabilities and appropriate uses of M&S (Report on Advanced Distributed Simulation and Report of the Acquisition Task Force on Modeling and Simulation, references (c) and (e)). In addition, a White House-led Task Force on Learning and Technology recommended that an extensive demonstration program be undertaken to promote dual-use and to better communicate the benefits of M&S in education and training.

3. Some elements of the Department of Defense and Congress have voiced skepticism about the return on investment associated with the development and use of M&S. Among the issues is the

concern that models and simulations require extensive investments that compete for the limited funds that are available for training and acquisition activities and the fear that the more extensive use of models and simulations will come at the expense of traditional training approaches (e.g., field training exercises, flight time) . To address this problem, the M&S community must demonstrate to potential users that the capabilities and benefits that , , M&S provide are more than commensurate with the investment required. Initial estimates strongly suggest that the effectiveness and cost of M&S are highly favorable for many applications in the Department of Defense (e.g., training, acquisition, mission rehearsal), but more active efforts must be undertaken to collect and interpret the required data and to make such results available in credible form to senior decision makers.

F. SUMMARY

1. In general, today's simulations:

- a. Are narrowly focused, stove-piped developments for each user community.
- b. Do not fully meet active, reserve or joint needs.
- c. Take too long to build.
- d. Cost too much to build and operate.
- e. Have not been verified, validated and accredited.
- f. Are not interoperable with other M&S assets that could be useful.
- g. Are not easily maintainable or extensible.

2. However, there has been a substantial increase in the attention and emphasis placed on M&S in the Department of Defense. Many excellent programs are underway and there is now a consensus on the need to interoperate and reuse models, simulations, and related products across DoD Component lines, across traditional communities (e.g., linking models and simulations to C⁴I systems), across functions (e.g. , sharing capabilities between operations and acquisition) , and across classes of models and simulations (e.g., linking live, virtual, and constructive simulations) . There is an opportunity to create simulations tailored to the user's need, at a greatly reduced cost in both time and money, and with elements of proven quality. patience, perseverance, and significant investment are required to overcome many challenging problems, but the potential payoff in military capability is extremely high.